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CULTURE, FERTILIZATION, AND FROST
PROTECTION OF CITRUS GROVES
IN THE GULF STATES.

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,

Washington, D. C., April 11, 1913.

SIR: Many requests are received at the Department of Agriculture for information on the methods employed in growing oranges and other citrus fruits in Florida and the Gulf States, and it is important that the Department be able to supply the desired information as fully as possible. In order to furnish this information in concise form, Prof. P. H. Rolfs, Director of the Agricultural Experiment Station of Florida, has revised Farmers' Bulletin 238, entitled "Citrus Fruit Growing in the Gulf States," and has divided the material contained in that publication into three parts, of which this paper is the third, as follows: "Sites, Soils, and Varieties for Citrus Groves in the Gulf States"; "Propagation of Citrus Trees in the Gulf States"; "Culture, Fertilization, and Frost Protection of Citrus Groves in the Gulf States." In this form the information will be more available for distribution in the territory directly concerned and will be of more service, it is believed, to prospective growers of citrus fruits and to planters already engaged in this industry. I have the honor to recommend that the paper be published as a Farmers' Bulletin.

Respectfully,

WM. A. TAYLOR,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

CONTENTS.

	Page.
Introduction.....	5
Preparation of the land.....	5
Setting out trees.....	6
Time and manner of setting out trees.....	6
Catch crops.....	7
Pruning.....	7
Fertilizers.....	8
Commercial fertilizers for Florida.....	8
Stable manure of doubtful utility.....	11
Injurious action of muck.....	12
Protection against cold.....	12
Protection by heat.....	12
Fuel oils.....	13
Heaters.....	13
Storage tanks.....	15
Cost of heating.....	15
Wood fires.....	16
Protection by irrigation.....	17
Protection by sheds.....	17
Top-working.....	18
Crown-working.....	19

ILLUSTRATIONS.

	Page.
FIG. 1. Crown-grafting an old orange stock.....	18
2. Ruby orange bud, inserted May 21 on a sprout from an old sweet-orange trunk, as it appeared on October 25.....	19
3. Ruby orange crown graft, inserted March 1, as it appeared on October 23.	20

CULTURE, FERTILIZATION, AND FROST PROTECTION OF CITRUS GROVES IN THE GULF STATES.

INTRODUCTION.

The growing of citrus fruits, an industry which has attained vast proportions in Florida, is receiving much attention in other Gulf States. The purpose of this bulletin is to answer some of the many inquiries constantly received by this Department and to act as a general guide for prospective planters who need definite advice upon questions of citrus-fruit growing. The information is necessarily of a very general character, but the essential factors are presented in a manner which, it is hoped, will enable planters to understand fully the fundamental principles involved.¹

PREPARATION OF THE LAND.

As a rule, the field chosen to be planted out to an orange grove is land with a native growth upon it. Usually the land is covered with forest trees. Various devices have been used for reducing the amount of labor necessary to get rid of this native growth, but up to the present time no substantial or decided progress has been made in the methods of clearing land. The most of the work is done by main strength and muscular labor. Where the native growth happens to be some form of hard wood, it is the usual practice to remove the trees and stumps. Some advantage is frequently obtained by the use of dynamite or other explosive in loosening the stumps. Where the native growth is pine woods or palm trees, the necessity for removing the stumps is not so great, though in the case of the former the stumps are usually taken out. In cabbage-palmetto hammocks some of the trees are left and used as nurse plants for a few years. The most economical course is to remove all trees, shrubs, and other forms of vegetation from the land and to clear it of all rocks and any other débris that may be found. Then the land may be broken up and put into a first-class state of tilth, which will permit careful staking and planting.

¹ For a discussion of other phases of this problem which can not be included here, since to treat them adequately would unduly increase the size of this bulletin, see Farmers' Bulletins 528, Sites, soils, and varieties for citrus groves in the Gulf States; 539, Propagation of citrus trees in the Gulf States; and 172, Scale insects and mites on citrus trees.

SETTING OUT TREES.

Usually the prospective orange grower buys trees from a nursery and sets them out as soon as the field has been cleared, wishing, of course, to get the trees on the land as soon as possible and to hasten the time when he may be selling fruit. Sometimes this is by no means the most profitable procedure. Land especially rich in organic matter and heavily matted with roots from the native growth would be decidedly better for having produced a crop or two of vegetables before the grove is planted. If for any reason it is not desirable to grow vegetables, a crop of weeds grown on it for a year would do much to sweeten the land preparatory to receiving the trees. A crop of cowpeas or velvet beans would be preferable, however.

The number of trees to be set out to the acre depends on the variety selected and the character of the land. Large-growing citrus trees, such as pamelos and the Valencia Late and Hart sweet oranges, should not be set closer than 100 to the acre, and on first-class soil 80 are enough. Smaller growing varieties, such as the mandarin group of oranges and the limes, should not be set closer than 200 trees to the acre. The character of the land will also need to be considered in setting out a grove. In a sandy loam rich in organic matter, especially in southern Florida, trees grow much more vigorously and in consequence should be set farther apart. Forty-nine trees to the acre, i. e., setting them 30 feet apart each way, is about as small a number as one can afford to plant. In the heavy clay soils trees grow less vigorously and may be set nearer together.

* TIME AND MANNER OF SETTING OUT TREES.

The time of setting out trees will depend on the location and the conditions. In the West Indies and south Florida trees may be set out at any time of the year when the land is ready and when there is sufficient moisture to favor their growth. In central Florida, the spring (February and March) is preferable. The same is true of north Florida, Louisiana, and Mississippi. In the extreme northern portions of the citrus-growing section it is usually better to wait until the danger of freezing weather is past. This will bring the date up to about the latter part of February. In setting out trees from the nursery, care should be taken to injure the roots as little as possible. Where trees can be taken up with a considerable ball of earth and transplanted in this way, they may be set out without any apparent check in growth. This, however, is not usually practicable.

When the trees are taken up, the roots should be carefully protected by means of wet cloths or moist moss and the trees set in holes

already prepared for them. If the ground is not already very moist, the addition of one or two pails of water will usually puddle the roots and cause the trees to grow promptly. At the time of setting out, the tops should be cut back to correspond closely to the condition of the roots. Complete defoliation is also advisable. The favorite size of tree to set out is one that has grown about 4 feet tall in the nursery and has several branches. Such trees are usually about an inch or an inch and a half in diameter at the crown.

CATCH CROPS.

As soon as the field has been set to a grove, cultivation may be begun. The kind and amount of cultivation will be determined by the character of the soil. Light, sandy soil should have shallow but careful cultivation. Heavy clay soils need thorough and deep working. Where there is an abundance of moisture supplied naturally to the soil, other crops may be grown to advantage. Where the soil is inclined to be dry and irrigation has to be practiced, intercropping is of doubtful utility. During the winter, vegetables may be planted and cultivated as in ordinary fields with decided advantage to the orange trees, unless the land is too dry. Leguminous cover crops may be planted as soon as the spring and summer rains begin. When fall droughts occur the cover crops will have to be removed to conserve the moisture of the soil. Cultivation should then be resumed. If the soil is inclined to be sterile the cover crop should be used as a mulch for the trees. If the ground is sufficiently fertile to permit it, the cover crop can be utilized for hay.

PRUNING.

"To prune or not to prune; that is the question." At many of the meetings of the horticultural societies the question of pruning has been vigorously discussed. There are many good reasons for pruning trees; on the other hand, there are reasons why trees should not be pruned. The question, then, must be decided by each individual. One point, however, has been very well settled, and that is that low-headed trees are preferable. Twenty-five or thirty years ago it was a common practice to have citrus trees trimmed high enough to permit a man to drive a cultivator under the branches. The severe cold of several winters has caused this custom to be very largely abandoned. In the southern part of Florida, where there is no danger from frost, it has been found that shading the ground by the limbs has been very beneficial to the grove. Another important advantage in low-headed trees is that the fruit may be gathered much more cheaply than from tall trees.

Nearly all orange growers will agree that the pruning out of dead and worthless branches is of benefit to the tree. The extent to which sound wood is pruned out, however, varies with the notions of the individual grower. Some of the most extensive and best growers in Florida practice no pruning at all. Diseased branches should always be cut out, removed from the orchard at once, and burned. Sprouts that start from below the bud must be removed, and this should be done as soon as possible. Water sprouts arising from the trunks and larger branches should also be removed.

A citrus tree should be kept in a low, compact form, but violent pruning, such as is often practiced in deciduous fruit orchards, is not only unnecessary but often absolutely harmful. Systematic pruning for special purposes is often necessary, but it must be done by a well-directed effort or more harm than good will result.

FERTILIZERS.

Under the general heading of fertilizers may be considered materials which are employed to enrich the soil or cause it to produce a heavier crop. Ordinarily the term "fertilizers" is restricted to such as are considered commercial articles, while the term "manure" is applied to organic offal and refuse accumulating on the farm. In some parts of the United States the term "guano" has been used to designate commercial fertilizers. Cover crops which are grown on the land for the purpose of enriching the soil are frequently called "green manures."

The kind of fertilizer required to produce a heavy crop of oranges varies greatly. In the West Indies, Mexico, Mississippi, Louisiana, and California the general constitution of the soil is so variable that no hard-and-fast rule can be given. In fact, in many cases it is doubtful whether the desired results attend the application of any or all the elements usually needed as plant food. While fertile soils produce trees of vigorous growth which often bear large crops of fruit, the possibilities are necessarily limited to what Nature will do; but in soils where one or more of the elements of plant food are present in insufficient quantity, the modeling of the fruit and the production of excellent qualities are more completely under the control of the skilled horticulturist.

COMMERCIAL FERTILIZERS FOR FLORIDA.

The kind and quantity of fertilizer necessary to produce a maximum crop of fine fruit depend entirely upon the soil in which the tree is growing. Many soils in the citrus regions contain an excess of all the elements necessary for the production of citrus fruits. When fer-

tilizers are applied under such conditions no beneficial effect can be noticed from their use. An orange tree planted in soil that contains large quantities of the necessary elements usually produces large fruit, but often of an indifferent character. Soils that are deficient in nitrogen, potash, and phosphoric acid can usually have these supplied from such sources and in such quantity as will produce fruit of the desired texture and consistency. It therefore happens that the finest and most delicious fruit is grown on rather sterile soil.

The entire pine woods of Florida may be said to be deficient in each of the three important elements of plant food—nitrogen, potash, and phosphoric acid. Soils are also found in which there is a deficiency of lime, so that frequently an addition of this element will prove of value. The hammock soils are usually sufficiently fertile to produce at least one crop, or even a few crops of fruit, without the addition of fertilizer. These, however, in time become depleted, and the elements of plant food then need to be supplied by substances from a commercial source.

In growing citrus fruits on soils that are deficient in all of the three important elements of plant food, a fertilizer of the following composition is desirable:

	Per cent.
Ammonia.....	4
Potash.....	10
Phosphoric acid (available).....	6

For growing nursery stock or for trees not of a bearing age the amount of potash in the formula may be reduced to 6 per cent, leaving the two other ingredients in about the above proportions.

The quantity of this fertilizer to be applied per acre will depend upon various conditions. About 15 or 20 pounds per year may be applied to each tree capable of producing 10 boxes of fruit, the quantity being decreased or increased from year to year, as results indicate. Calculating this on the basis of 100 trees per acre, 1,500 pounds per acre per year would be used for young bearing trees. Double this amount is very frequently applied, and sometimes three times as much is used.

The following table gives approximately the amount of material needed per acre for bearing trees to supply a quantity of fertilizer equal in fertilizing constituents to 1,500 pounds of the foregoing formula:

	Pounds.
(1) Sulphate of ammonia.....	250
(2) { Sulphate of potash, high grade.....	300
{ Or sulphate of potash magnesla (low-grade sulphate of potash)	550
(3) { Dissolved boneblack.....	550
{ Or acid phosphate, 14 per cent available phosphoric acid.....	850

In the case of nursery stock and growing trees, 2 per cent of the ammonia may be derived from an organic source. This would require approximately the following ingredients:

	Pounds.
(1) Sulphate of ammonia.....	125
(2) Dried blood.....	100
(3) { Sulphate of potash, high grade.....	200
{ Or sulphate of potash magnesla (low-grade sulphate of potash).....	350
(4) { Dissolved boneblack.....	550
{ Or acid phosphate, 14 per cent available phosphoric acid.....	850

If there is any tendency toward die-back the dried blood should be omitted and the amount of sulphate of ammonia increased to 250 pounds. If a quick-acting fertilizer is wanted, nitrate of soda (100 pounds) may be employed in place of dried blood.

Citrus-fruit growers wishing to compound their own fertilizers should give due regard to the substances from which the different qualities are derived.

Organic ammonia, as found in cottonseed meal, dried blood, guano, and the various stable manures, is likely to produce a soft, rapid growth, and in certain sections, especially in Florida, its continued use is almost certain to produce die-back.

Nitrate of soda is soon taken up by the trees, but is easily washed out of the soil. Where it is used as the only source of nitrogen it has to be repeated from four to eight times each year, varying with the amount of rainfall and the character of soil.

Sulphate of ammonia is much slower in becoming available to the trees and seems to be retained in the soil much more tenaciously than nitrate of soda, so that it need not be applied oftener than two to four times a year.

In the use of potash there is very little choice between the low-grade sulphate, which is also called the double salts of potash and magnesin, and the high-grade sulphate of potash.

In selecting phosphates, preference is given to dissolved bone or dissolved boneblack over dissolved rock phosphate, although some experienced orange growers consider the phosphoric acid derived from dissolved rock as good as that obtained from dissolved bone. Thomas slag may be employed to good advantage, especially on soils giving an acid reaction.

The ammonia is washed out of the soil in great quantities by frequent and heavy rains. Potash is washed out to a less degree and phosphoric acid only to a slight extent, while lime, or calcium, is lost in large quantities. The quantity of these elements lost will vary according to the nature of the soil and the amount of heavy rainfall occurring. The ideal way of fertilizing would be to make an application of phosphoric acid in the spring before the rainy season has

begun; to make two applications of potash—one in the early spring at the time of applying the phosphate and another in the fall after the rainy season has passed; and to make four or more applications of ammonia—one with each application of the potash and two or more at equal intervals between, except during the dormant winter season.

The following example will serve to illustrate the point: Let us suppose that a grove needs 1,500 pounds of fertilizer per acre per year of the normal formula, that is, 4 per cent ammonia, 10 per cent potash, and 6 per cent phosphoric acid. In the spring, therefore, before the rainy season has begun, we would apply the entire allowance of phosphoric acid, or 850 pounds of 14 per cent acid phosphate; one-half the potash, or 150 pounds of high-grade sulphate of potash; and one-fourth the ammonia, or 62½ pounds of high-grade sulphate of ammonia. These ingredients may be mixed and applied in the usual way. Care must be exercised, however, since such a mixture is a very concentrated fertilizer, and if applied in a narrow zone around the tree injury may result when the weather conditions make possible the too rapid assimilation of the chemicals or when the nature of the soil itself is such that the fertilizer is taken up too quickly.

For the fall application, 150 pounds of high-grade sulphate of potash should be mixed with 62½ pounds of high-grade sulphate of ammonia. The remaining 125 pounds of sulphate of ammonia should be evenly divided and applied as the conditions indicate. In this way the amount of plant food that is contained in 1,500 pounds of fertilizer of standard formula would be applied during the year.

The proper regulation of the amount of ammonia to be applied is the greatest difficulty in preparing a complete fertilizer formula. The presence of this element in too large or too small quantities in the soil or in the fertilizer appears to give more trouble than any other ingredient. Groves are very frequently injured by large applications of ammonia. A very common practice is to make only two applications a year of a complete fertilizer—one during the spring and one during the fall. Other growers make three applications—one during the early spring, one later in the spring, and another during the fall.

STABLE MANURE OF DOUBTFUL UTILITY.¹

The benefits of stable or barn manure, which is largely used by many growers, are also very doubtful. The fruits produced by nitrogen from this source are usually large, coarse, thick-skinned, and of inferior flavor. If barn manure is used, however, each tree should receive only a small quantity, and where it is the main element of fertilization liberal dressings of potash should occasionally be applied to counterbalance the nitrogeous fertilizer.

¹ See Yearbook, U. S. Department of Agriculture, for 1894, pp. 195 and 196.

INJURIOUS ACTION OF MUCK.¹

Some growers claim that since muck is largely decaying vegetable matter it should be applied to the grove in large quantities, either raw or composted with sulphate of potash, etc. While this has occasionally given excellent results, its extensive use has often done serious injury. In order to obtain a smooth, thin-skinned, juicy fruit with few or no seeds, we must vary the fertilization which the plant receives in its wild state. The tendency of all organic manures rich in nitrogen is to stimulate large, sickly growth. Groves which have had liberal dressings of muck are frequently much diseased; their crops are light, the oranges coarse, thick-skinned, and sour, the fruit drops prematurely, and the trees are often affected with die-back. What has been said of muck applies to a greater or less extent to the various forms of organic nitrogen used.

What has been said about the effect of muck and barn manure on the quality of the fruit applies equally to the effects produced by cottonseed meal, blood and bone, tankage, etc. In general, organic fertilizers do not stimulate fruiting to the same extent as the mineral fertilizers.

PROTECTION AGAINST COLD.

The disastrous freezes of 1894, 1895, and 1899 in Florida and those of 1912 and 1913 in California have caused the orange grower to cast about for some means of protection against a sudden cold wave. Two general methods have been practiced: The first is that of warming the air without providing shelter and the second is that of providing a shed or shelter for the trees.

The methods of raising the temperature by means of fires, as described in the following paragraphs, can not be relied on if the cold weather is accompanied by high winds or rainfall. In a portion of Florida during the heavy freeze of 1899 not only a heavy rainfall but heavy winds accompanied the cold. All attempts at building fires were useless, and even if they could have been built the wind would soon have carried the warm air out of the groves.

When a very moderate breeze is blowing and the temperature falls only 4 or 5 degrees below the danger point, fires should be increased on the windward side, perhaps doubled, at the expense of those in the interior, but fires should not be extinguished in the interior of the grove, merely reduced.

PROTECTION BY HEAT.

The burning of different kinds of fuel in an orchard for the purpose of raising the temperature has been employed a great many

¹ See Yearbook, U. S. Department of Agriculture, for 1894, pp. 195 and 196.

times. The success attending the work varies under different circumstances and with different conditions. When the drop in temperature is accompanied by a heavy windstorm and rain or sleet, it is almost impossible to accomplish anything in the way of orchard heating. Fortunately, freezing weather in the citrus regions is usually accompanied by a rather still atmosphere and freedom from rain or snow.

A great many kinds of fuel have been employed for orchard heating. Wood was probably the first, and it is still employed to some extent. Coal, coke, and fuel oil have all been used to a greater or less extent. Each of these fuels may have special advantages over others in some particular place. In general, it may be said that the fuel-oil method has given satisfaction more frequently than all the others combined. To discuss all of the methods fully is quite beyond the purpose of this bulletin.

FUEL OILS.

This term includes a variety of materials known under many different trade names. In general, they are the heavy residue left after the lighter oils contained in the petroleum have been removed. A fuel oil known as crude oil is said to contain a large quantity of asphaltum, which becomes quite troublesome. The asphaltum remains as a residue in the bottom of the heaters and interferes with the heating when the fuel burns low.

HEATERS.

The varieties and styles of heaters offered by the trade are nearly as numerous as the varieties of fuels. Usually the more complicated in construction the heater is, the less efficient it becomes in its practical work in the orchard. Even a 10-pound lard pail, holding more than a gallon of fuel oil, compares very favorably in efficiency with the patented heaters, in some cases even proving superior to them. The lard-pail type of heater, made from heavy sheet metal and holding about 5 quarts of oil, can usually be purchased from heater manufacturers at 10 or 12 cents apiece when ordered in carload lots. In this type of heater the quantity of fuel used and the heat given off decrease gradually as the supply in the heater is consumed.

The lard-pail type of heater holding a gallon of fuel oil will burn for $3\frac{1}{4}$ to 4 hours, varying with the kind of fuel oil used and weather conditions, giving off about one-half as much heat toward the close as at the beginning of the charge. When a soot arrester is used, the quantity of fuel consumed in an hour is much reduced, but at the same

time a correspondingly smaller amount of heat is given off. There are a number of heaters that hold a much larger quantity of fuel oil. Most of these are so constructed, either by means of a soot arrester or otherwise, that the quantity of oil burned can be regulated. Ordinarily these are to be preferred to the smaller type, since when freezing weather occurs it is usually of more than four hours' duration. The minimum temperature is very likely to occur about sunrise. Refilling in the dark is difficult and wasteful.

The type of heater with a sliding top to regulate the area of the burning surface has worked quite satisfactorily. Roughly speaking, 44 square inches of free burning surface will consume a gallon of fuel oil in four hours. It has been pretty clearly demonstrated by experiment that it will require the same quantity of oil to raise the temperature 5 degrees in an orchard, whether few or many heaters are used. When many heaters are used the temperature in the orchard can be maintained much more evenly. The number of burners needed per acre to raise the temperature 5 degrees will vary greatly, according to the favorable or unfavorable climatic conditions and the condition of the grove. A small grove of large trees closely planted and surrounded by a dense hammock will pass unharmed through a freeze of 25° F., while considerable damage would be done in a grove not so protected. Likewise, the number of heaters required in the former grove would be fewer than in an open grove where the trees are small and only a few to the acre.

From 50 to 100 heaters and from 100 to 200 gallons of fuel oil per acre for each night when heating is necessary is a reasonably safe estimate in a grove 7 to 10 years old. This number of heaters and quantity of fuel oil will probably keep the temperature 5 degrees above the surrounding atmosphere if the wind is not blowing more than 4 or 5 miles an hour. Ordinarily the heaters are distributed evenly throughout the grove, placing one in every center between four trees. This requires about as many heaters as there are trees in the grove, and is a poor rule to follow absolutely, since a grove of small trees planted far apart will not hold the heat as well as a grove of large trees planted closely. Every grove owner will have abundant latitude to use his own judgment as to the effect of the exposure of his grove and the other elements that enter into the question of orchard heating.

Every grove supplied with heaters should have in it a thermometer that will sound an alarm when the temperature approaches the danger point. Such an instrument can be obtained for from \$7 to \$20 from instrument manufacturers and dealers. The thermometer should be placed in that part of the grove in which the danger from

frost is greatest, and the wires should run to the house or central office.

The danger point will vary with conditions. At blooming time the danger point is highest and injury may then occur whether the temperature goes down to 32° F. or not. Mature fruit is almost certain to remain unharmed unless the minimum temperature falls below 28° F. Trees in a fully dormant condition will remain unharmed at 24° F., but when full dormancy has passed the trees become increasingly sensitive to cold. When in full growth, frost, no matter at what temperature it occurs, will destroy the tender tissues.

Every grove owner should be in direct telephone communication with the United States Weather Bureau, in order to receive warnings of probable frosts and freezes. All the important fruit-growing sections receive this information regularly over long-distance telephones.

STORAGE TANKS.

The fuel oil should be stored in a tank located preferably in the grove. Where possible, it should be so placed as to allow the oil to be siphoned directly into it from the car tank, and then from it into the wagon tank. The storage tank should always be so located as to enable one to run the fuel oil into the wagon tank by gravity. Pumps work satisfactorily in warm weather, but are apt to be troublesome during a cold spell. They also require extra labor, which could be more advantageously employed in the grove. A break in a pump will cause delay and may make the fuel inaccessible, thus rendering the whole plant ineffective.

Fuel oil may be stored in a variety of receptacles, the least desirable of which are barrels. Concrete tanks or cisterns with tops, such as are constructed for holding water, will be found useful. The inner surface should be finished with cement plaster and finally given two or three coats of asphaltum paint. Steel water tanks are in common use. Wooden tanks similar to water tanks, made of upright 2-inch planks, are commonly used and seem to be thoroughly practicable. Some grove owners have tanks such as are used on tank cars for hauling fuel oil, but these would seem to be unnecessarily expensive.

COST OF HEATING.

The estimated cost of preparing to heat a 10-acre grove will vary within certain limits. No two groves would be located exactly alike as to the cost of heating. The distance from the railroad, number of times to be fired, and variation in price of labor all come in as variables.

The following table gives an approximate cost for a 10-acre grove:

500 to 1,000 heaters, at 40 cents.....	\$200 to \$400
One steel wagon tank.....	25 to 30
Torches and gasoline can for lighting.....	10 to 12
Thermometers and installing.....	12 to 25
3,000 to 6,000 gallons of fuel oil.....	90 to 180
Storage tank for fuel oil.....	100 to 300
Total.....	437 to 947

After the equipment has been installed the expense is comparatively light and includes mainly the annual depreciation, care of outfit, fuel oil burned, transfer to storage tank, and labor. The last item will vary from year to year. When no firing is needed this item will be comparatively light. At firing time it will require two or three additional men to take care of 10 acres. An allowance of \$6 to \$10 for each night fired should be ample, including the cost of distributing the fuel oil for the next charge. In extensive groves and where large-size heaters are used, one man to 10 acres will be sufficient to take care of the fires, but additional labor will be needed to replenish the fuel.

WOOD FIRES.

In a wooded country the form of protection against cold afforded by fires is cheap and at the same time very effective when a still cold occurs. The wood is piled in the centers of the squares, varying in quantity from three or four to a half-dozen or a dozen sticks of cord wood. When a freeze is predicted, the watchers notice the thermometer and by the time the cold approaches within 2 or 3 degrees of the danger point, which is 28° F. for fruit and 24° F. for foliage, fires are started in alternate squares. These will usually heat the grove some 4 or 5 degrees. If the cold continues to increase, all the piles of wood are started. It is of course necessary to have on hand a reserve stock of fuel in such an emergency. Shortly after the sun rises the next morning the temperature will usually have risen again, so there will no longer be any danger to the fruit or trees. If there is no favorable change in the weather, the cold on the second night is quite likely to be more severe than on the first. Firing then must be begun much earlier, and consequently a greater quantity of wood will be needed.

Owing to the large amount of labor involved and the difficulty of securing efficient help, this form of orchard heating has been largely abandoned.

PROTECTION BY IRRIGATION.

In the citrus-growing sections the water that is freshly pumped from the soil is quite warm, ranging from 50° to 74° F. When this water is carried through a grove in irrigating ditches it gives off a considerable amount of heat and has been used effectively in some instances where the temperature has fallen but slightly below the danger point.

Arrangements have also been made to throw this water into the air from spray nozzles. This is somewhat more effective than when the same quantity of water is carried through irrigating ditches, but can not be relied upon as being sufficient during extremely cold spells. During one cold wave the orchard of Mr. Theodore Mead, at Oviedo, Fla., was protected in this way. During one night the temperature fell considerably below the freezing point. The next morning the trees were so heavily coated with ice that some of the branches broke. The following summer the trees bore a crop of fruit.

The waters from artesian wells have also been used for the purpose of warming citrus groves, this water being quite warm, running into the sixties usually and as high as 74° F. in some wells. While this use of water does some good and protects that portion of the grove in the immediate vicinity of the large flow, the amount of heat given off is small and the volume of water supplied is not considered large enough to protect the grove during severe freezes.

PROTECTION BY SHEDS.

The most successful method of protecting citrus trees from extremely cold weather is that of building a shed over the grove. At first thought this would seem to be entirely too expensive and not at all feasible, but the sheds have now been used long enough to demonstrate fully that they are not only possible but practicable. There are several modifications of the shed.

This method was successfully employed immediately after the great freezes and was profitable while Florida oranges brought a high price. Orange sheds now occur to a limited extent and only in regions where great damage from cold formerly occurred. These sheds are simple structures, having a flat roof or cover held up by posts. The posts are properly braced and hold the cover from 12 to 16 feet above the ground. Some of the movable tops are made solid, while those with stationary tops are made of slats or laths so placed as to give either a half or third shade.

TOP-WORKING.

It sometimes happens that a grove is planted out to a variety that does not prove prolific, or one that may be unprofitable to market. In such a case it becomes necessary to abandon the grove or to top-work the trees. With the trees in a healthy and vigorous condition most or all of the top should be removed, only two or three vigorous limbs being left. Buds of the desired variety may be inserted into the remaining limbs. This cutting away of most of the top causes a heavy flow of sap into the smaller limbs which remain. In such cases the buds will "take" where they would fail if the top of the tree had not been vigorously cut back.

Another way of top-working is to cut away nearly all of the top and then wait for sprouts to start. After the sprouts have reached a

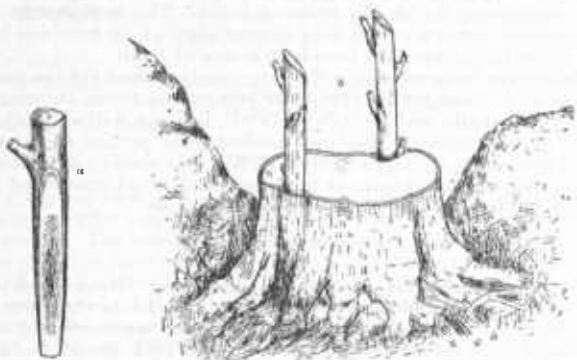


FIG. 1.—Crown-grafting an old orange stock: a, Base of scion, showing slanting cut; b, method of inserting scion. (From Yearbook, U. S. Department of Agriculture, for 1895.)

size of about half an inch in diameter they may be budded, and the bud will take readily. When trees have been cut back severely, the bodies and the larger limbs should receive a heavy coat of whitewash to protect them against sun scalding.

Before top-working, the orchardist should be well acquainted with his grove and soil. In a very large portion of Florida severe top-pruning results in die-back unless proper fertilization and soil treatment accompany the work.

In California and Louisiana it appears to be safe to remove the entire top and to work buds into the large limbs. For top-working, the shield bud and sprig graft may be used to best advantage.

CROWN-WORKING.

At times it becomes desirable not to permit the body of the tree to remain. In such cases it may be cut off at the ground line. Some citrus trees, especially limes, resent treatment of this kind and fail to grow after the top has been entirely cut off. The ordinary citrus stock, however, is almost certain to sprout again if treated in this way. Large areas, 20 to 40 acres in extent, were sprouted in this way after the great freezes of 1894 and 1895 in Florida without the loss of a single healthy stump.

Trees that have been cut back in this way may be crown-worked or crown-grafted, as illustrated in figure 1, the sprig being inserted in the portion of the crown that will take it most easily. By slipping the scion into the portion of the crown where the bark may be raised without breaking, the work may be done without the use of wax or other binding material. After the scion has been inserted, moist earth should be raked over the crown and around the scion, covering them until they have "taken," and then exposing the tips. Where this work is done by experienced hands, only a very small percentage of the crowns fail in taking one or more sprigs. Those that fail to take may be worked again or left to produce sprouts and then budded into these sprouts. By using three or four such scions in a crown 4 or more inches in diameter and doing the work during February or the early part of March the percentage of loss sustained will not be very great.

Another method of renewing such an orchard is to wait until the sprouts have started from the crown or the main roots. After these sprouts have reached a size of half an inch or so in diameter, buds are inserted as low down as practicable. In doing this, however, a con-



FIG. 2.—Ruby orange bud, inserted May 21, on a sprout from an old sweet-orange trunk, as it appeared on October 25. (From Yearbook, U. S. Department of Agriculture, for 1895.)

siderable loss of time will be sustained in waiting, first, for the sprouts to start and then, again, in cutting them back to make the buds sprout. The loss of time is strikingly illustrated by the two



FIG. 3.—Ruby orange crown graft, inserted March 1, as it appeared on October 23.

accompanying figures made from photographs (figs. 2 and 3). This method of budding sprouts, although it results in some loss of time, is nevertheless very commonly used by growers because of its convenience.